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Research on the Problems and Countermeasures in the Practical Teaching of Concrete Foundation Experiments under the Background of New Engineering Education

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Abstract: The Master Teacher Studio of basic education came into being with the new curriculum reform, which has become a new mechanism for the construction of teaching staff in the social situation in China. As a brand-new way in the construction of teaching staff in the new era, through reviewing the relevant research, it's found that the focus of academic circles on Master Teacher Studio in is mainly in four aspects: clarifying the conceptual boundary, seeking theoretical support, defining the functional orientation and exploring status quo of development. The exploration of the research process is not only a process of summary, but also a process of reflection. By reviewing relevant research, reflecting on the problems that have appeared in the process of building Master Teacher Studio in basic education, clarifying the development path of Master Teacher Studio and further affirming its advantages to the construction of teaching staff in China contexts.

Keywords: Master teacher; Master Teacher Studio; Construction of teaching staff; Teachers' professional development

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1. Introduction

The new concept of engineering education comes into being with the rapid progress of science, technology and the continuous innovation in the field of engineering. The core of this concept is to focus on the cross-border integration of disciplines and strengthen the training of practical innovation ability. The Engineering practice training education system is built to adapt to social development [1]. In the field of civil engineering, concrete as a cornerstone building material, its performance optimization and application innovation are directly related to the safety, durability, and economic benefits of buildings. Therefore, "Concrete foundation experiment" as an indispensable practical course of inorganic non-metallic materials engineering, its importance has become increasingly prominent. In the context of new engineering education, the teaching mode of the traditional concrete basic experiment course is faced with severe challenges. It mainly focuses too much on theoretical teaching and basic operation, and cannot meet the urgent demand of the industry for engineering and technical talents with high quality and high innovation ability [2]. In view of this, the research team will adopt diversified research methods, including comprehensive literature analysis, extensive questionnaire survey, selected case analysis, and in-depth experimental research, etc.. At present, the content of experimental teaching in most colleges and universities in China is outdated and out of step with engineering practice and the frontier of discipline development [3]. Therefore, the teaching team reformed the concrete foundation experiment course. New technologies need to be integrated into the teaching content, such as BIM and prefabricated concrete structures. At the same time, the use of the "Internet +" platform and rich teaching means to improve the teaching effect.

Based on this, the author's team will closely integrate the new engineering education concept. They carefully designed and implemented a series of experimental teaching reform measures. The results are verified by comparative experimental science. This study is to improve the quality and effectiveness of concrete foundation experiment teaching. It also focuses on stimulating students' practical potential and innovative thinking to meet society's new expectations of talent.

2. Common problems in practice teaching

In the teaching of the concrete foundation experiment course, traditional verification experiment still occupies a dominant position, which limits the cultivation of students' innovative ability and practical ability to a certain extent [5].

2.1. The teaching philosophy of "emphasizing scientific research over teaching and theoretical knowledge over practical application"

The existing experimental teaching methods are more theoretical and less practical, resulting in poor practical ability in some students [6]. Generally speaking, teachers teach theories and demonstrate experiments. While students do things step by step, they lack thinking and fail to achieve the effect of educating people [7].

(1) The disconnect between theory and practice: Overemphasis on the study of theoretical knowledge and neglect of practical training will cause students to master a lot of theoretical knowledge. But when they apply the knowledge to solve the problems on the engineering site, they will be at a loss.

(2) Lack of innovation ability: Without systematic and specialized practical training, students' innovative thinking and practical ability will not be fully exercised. They may be trapped in the framework of "book knowledge". They difficultly jump out of the shackles of traditional thinking models, and cannot thus innovate and break through in the face of complex engineering problems.

(3) Lack of engineering quality training: In practical teaching, theoretical education is generally given importance, and it is difficult to form a good comprehensive quality, which will not only affect the learning effect of students, but also affect their future career development [8].

(4) Lack of learning interest: boring theoretical knowledge, simple and unchallenged basic skills training, and the lack of practical opportunities in the teaching environment can easily make students tired of learning, reduce their interest in learning, and motivation. When students feel that what they have learned is out of touch with their real life and work, they may have a psychological resistance to learning, thus affecting the overall teaching effect.

(5) Mismatch with industry needs: The neglect of students' practical and innovative abilities in the existing teaching methods will lead to a large gap. This mismatch will make students uncompetitive in the job market, while also failing to meet the industry's demand for highly qualified engineering talents, and will also affect the quality and reputation of the entire education system.

2.2. The backward content of experimental textbooks

(1) Students' level: The backward content may cause students to be unable to systematically learn the relevant knowledge of concrete basic experiments. The experimental teaching materials away from the industry cannot provide experimental content and operational guidance in line with the actual work scenarios, resulting in a lack of students' ability to solve practical problems and difficulty in adapting to future work needs. Too simple an experiment content may make students feel bored and difficult to receive good learning results.

(2) Teaching quality level: Non-standard experimental materials will directly affect teachers' teaching quality and

teaching effect. It is difficult for teachers to carry out teaching, so there is no way for colleges and universities to achieve their teaching goals. Without the needs of the industry, the school may invest a lot of resources to buy unnecessary experimental equipment or materials, and these resources are not fully integrated into the actual teaching, resulting in a waste of resources.

(3) Industry demand level: The experimental teaching materials that are out of step with the needs of the industry may not be able to meet the market demand for concrete professionals, resulting in a mismatch between talent supply and demand. The concrete industry is a constantly developing field; new technologies, new materials, and new processes emerge in an endless stream.

(4) Education system level: The education system should be constantly adjusted and updated with the development of society and industry. If the content of the experimental materials is not standardized and out of touch with the needs of the industry, then the entire education system will be greatly reduced in terms of adaptability and flexibility.

2.3. Single experimental teaching mode

In the "concrete foundation experiment" teaching, if the teaching mode is simple for a long time, it may lead to the following five levels of progressive consequences, forming a deep impact from knowledge mastery to career development.

(1) Rigid thinking and fragmented knowledge: Students only memorize standard experimental steps instead of understanding principles. The inability to establish a correlation between concrete material properties (such as creep and shrinkage) and the stability of the foundation engineering results in a "not seeing the forest for the trees" phenomenon when analyzing practical engineering problems.

(2) Practice gap and innovation suffocation: Students are familiar with ideal experimental conditions, but cannot cope with complex site environments (such as temperature changes, construction errors). A university study shows that such students need an additional 3–6 months to adjust to the job. When it comes to quality issues, such as cracks in concrete, they apply textbook solutions rather than innovative solutions combined with field data. Feedback from companies shows that the completion rate of such graduate independent projects is 20% below the industry average.

(3) Learning motivation and professional identity decline: According to the investigation of an engineering college, the plagiarism rate of students in the class with a single teaching mode is 47% higher than that in the class with a diversified teaching mode, which reflects the loss of intrinsic learning motivation. Due to the lack of engineering ethics education (such as excessive pursuit of intensity and neglect of environmental protection), it is difficult for students to establish a sense of professional mission for engineers. Industry turnover rate data show that the first-job turnover rate of this group is 35% higher than that of the multi-training group.

(4) Mass closed loop failure: The standardized test made 58% of students get high scores, but could not explain the reasons for data fluctuations, forming a false teaching quality of "high scores but low ability." The lack of collaborative experimental projects in related courses such as material mechanics and structural engineering leads to the fragmentation of the knowledge system, and the response speed of students to solve interdisciplinary problems is 60% slower than that of the comprehensive training group.

(5) Technology iteration lags behind: Low acceptance of new materials. Students with a single instruction are 70 percent less likely to be exposed to new types of concrete, such as ultra-high performance concrete, slowing the industry's technology update process. With the increase of engineering innovation costs, engineers who lack systematic experiment training need to incur 40% more trial-and-error costs in the optimization design stage of basic engineering, which affects the efficiency of building industrialization transformation.

2.4. Students' weak sense of innovation and entrepreneurship

(1) The design scheme is rigid and the technology update lags behind. Students over-rely on textbook cases,

mechanically imitate traditional concrete foundation forms (such as strip foundation, raft foundation), and ignore actual variables such as geological conditions and load characteristics. The homogeneity of the design scheme can not cope with complex engineering scenarios (such as the deep foundation pit support of high-rise buildings), and reduce the efficiency of industry technology iteration.

(2) Limited ability to solve engineering problems. In the face of concrete cracking, temperature stress and other practical problems, the lack of multi-scheme comparison thinking. For example, relying only on the expansion agent recommended by the specification to control cracks, fiber concrete or smart monitoring technologies were not explored. During construction, it is easy to rework due to scheme defects and increase the cost. According to industry statistics, engineering changes caused by conservative design or single solution account for 12% to 15% of the total cost of a project.

(3) Missed opportunities for entrepreneurship and innovation. Lack of awareness to turn technology into business value. For example, after mastering high performance concrete technology, it is not considered to apply it to prefabricated component entrepreneurship or green building materials development. The entrepreneurship rate of the construction industry is low, and the talent gap in emerging fields (such as 3D printed concrete and prefabricated housing) is obvious.

(4) Poor adaptability to career development. Low sensitivity to industry trends (such as BIM collaborative design, building digitization), only master the basic construction technology, did not learn the whole life cycle management thinking. Most of the graduates are concentrated in construction line positions, and it is difficult to qualify for high-paying positions such as design consulting and project management.

(5) Industry technology iteration lag risk. A higher vocational college still adopts traditional wood formwork technology in concrete practical training, and does not introduce digital twin technology to simulate the pouring process, resulting in insufficient spatial cognition of students, which affects the construction accuracy of complex nodes (such as variable section columns).

Talent training lags behind the development of technology, restricting the overall innovation process of the industry.

3. Study on coping methods

Concrete foundation teaching has realized the transformation from “knowledge transfer” to “ability construction” through the four-dimensional linkage reform of “idea-content-model-cooperation,” which not only meets the needs of the industry but also instills lasting impetus for the career development of students.

3.1. Innovation of teaching concept: From “Knowledge Infusion” to “Thinking Empowerment”

(1) Role transition: Using the “flipped classroom” model, students learn the theory of concrete mix design through video before class, and teachers guide discussions on material adjustment schemes under special working conditions (such as frozen areas) during class. The interactive data of “rain class” was included in the assessment, the number of students’ questions increased by three times, and the score of program innovation increased by 28%.

(2) Critical thinking training: The study sets up a “concrete failure case analysis course,” such as the Storma Bridge collapse in Norway, to guide students to deduce the causes from multiple aspects of materials, construction and design.

3.2. Upgrading of experimental teaching materials: From “confirmatory experiment” to “Engineering Project”

(1) Project-based experimental design: To develop the “Intelligent curing sensor” project, students need to complete the whole process from concrete hydration heat monitoring to data modeling. Combined with the Internet of

Things technology, the sensor accuracy is up to ± 0.5 ℃, and the invention patent is authorized.

(2) Cutting-edge technology embedding: With the help of 3D printing experiments, the student team printed variable-section columns (simulating Zaha buildings) to optimize material mobility through parametric design. The experiment shows that adding 0.8% polypropylene fiber can increase the compressive strength of the printed component by 22%. In a deep foundation pit support project, students simulated earth pressure distribution with BIM, optimized the spacing of supporting piles, and reduced the cost by 18%.

3.3. Reconstruction of teaching mode: From "One-way Teaching" to "Multiple Interaction"

(1) Blended learning ecology: Online, using virtual reality (VR) technology to simulate concrete placement, students can "step inside" the structure to observe the development of cracks. Offline, the "72-hour quick challenge" was carried out, and students completed the whole process from geological exploration to program report in groups, and the winning program was funded by the enterprise.

(2) Interdisciplinary collaboration: The "Concrete carbon emission calculation Model" was developed in cooperation with the computer major, and the students comprehensively considered the variables such as material transportation and construction technology, and some of the results were written into the industry white paper.

3.4. Deepening school-enterprise cooperation: From "Loose internship" to "Integration of industry and Education"

(1) Dual education mechanism: Jointly build a "Digital construction laboratory" with Guanglian, and corporate tutors participate in the course design, and students can obtain BIM certification credits. The employment rate of graduates in prefabricated construction enterprises increased by 35%, and the starting salary was 12% higher than the traditional model.

(2) Technology transformation platform: The "Self-compacted concrete 3D printing material" developed by the student team has been supported by the school-enterprise cooperation fund and has been applied to the production of municipal pipelines, saving the material cost of more than 500,000 yuan per year. The number of prizes won by students in competitions above the provincial level has increased by four times, and the annual growth rate of business incubation projects is 30%. The student employment competitiveness in the cooperative enterprise satisfaction reached 92%, and the intern retention rate increased to 65%. In the industry influence, 2 teaching reform achievements won the school-level teaching achievement award.

4. Conclusion

Based on the employment situation and the demand for talents in recent years, this paper analyzes the common problems existing in the teaching of "Concrete Basic Experiment Course," and combines the new engineering education concept to implement the four-in-one innovation of "thinking empowerment - engineering projects - diverse interaction - integration of production and education," which helps the technology iteration and sustainable development of the construction industry and provides a scalable paradigm for the reform of engineering education. The details are as follows:

(1) Concept innovation is the core driving force, and students' innovation potential can be activated through a flipped classroom and critical thinking training;

(2) Content upgrading needs to connect with the forefront of the industry, and the integration of project-based experiments with 3D printing, BIM, and other technologies significantly improves practical efficiency;

(3) Model reconstruction emphasizes situational learning, VR simulation, and interdisciplinary collaboration effectively bridge the gap between theory and practice;

(4) The deepening of school-enterprise cooperation requires the establishment of a dual education mechanism, and the technology transformation platform promotes the industrialization of achievements.

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